Narrative Bottom Deposits Standard Implementation Procedures for Wadeable, Perennial Streams

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Executive Summary

This document sets forth implementation procedures for the narrative "bottom deposits" water quality standard found at A.A.C. R18-11-108(A)(1). The document explains ADEQ's approach to objectively determining compliance with this narrative bottom deposits standard. The narrative bottom deposits standard states:

> *"A surface water shall not contain pollutants in amounts or combinations that settle to form bottom deposits that inhibit or prohibit the habitation, growth, or propagation of aquatic life."*

This narrative standard is intended to prevent excessive sedimentation and siltation in amounts that adversely affect aquatic life. Excessive sediment alters aquatic habitats and suffocates fish eggs and bottom-dwelling organisms. Clean stream bottom substrates are essential for the health of many fish and aquatic insect communities. Habitat degradation due to sedimentation occurs when key habitat components such as spawning gravels and cobble surfaces are covered by fine sediment, decreasing inter-gravel oxygen transfer and reducing or eliminating the quality and quantity of pool and interstitial habitat for fish, benthic macroinvertebrates and algae. Fine sediment is defined as particles that are less than 2 mm in size (i.e., sand, clay, and silt).

ADEQ proposes to determine the percentage of fine sediments to determine compliance with the narrative bottom deposits standard. ADEQ proposes to use separate bottom deposits criteria for warm and cold water streams, based upon our interpretation of the existing scientific literature. Fine sediment levels of <30% fines for cold water streams and <50% fines for warm water streams are required to protect aquatic life. These fine sediment thresholds constitute the objective criteria that ADEQ will use to determine compliance with the narrative bottom deposits standard.

ADEQ proposes to use a minimum percent fines threshold of 30% for cold water streams. The scientific literature indicates that negative effects to salmonid propagation (e.g., trout) are shown to occur when the percentage of fine sediment in riffle habitats is above this threshold. Bjornn et. al (1977) found that when the percentage of fine sediment exceeds 20% to 30% in spawning riffles, the survival and emergence of salmonid embryos begins to decline. ADEQ's "riffle pebble count" field procedure must be used to determine the percentage of fine sediments in the riffle habitats of a cold water stream (Appendix A).

ADEQ proposes to use a minimum percent fines threshold of 50% for warm water streams. This threshold is a composite of multiple macroinvertebrate species tolerance values developed by Relyea et al. (2000), many of which reside in Arizona's warm water streams. This criterion represents a loss of habitation by aquatic life, namely the aquatic insects. ADEQ has supporting macroinvertebrate data indicating that sediment effects to macroinvertebrates occur at levels of 40-50% fines in San Pedro River streams (Spindler, 2004). ADEQ's "reach level" or zig-zag pebble count procedure must be used to determine compliance with the warm water bottom deposits criterion (Appendix B).

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Introduction

Excessive sediment alters aquatic habitats, suffocates fish eggs and bottom-dwelling organisms, interferes with drinking water treatment processes, and impairs the recreational uses of rivers and streams. Clean stream bottom substrates are essential for the health of many fish and aquatic insect communities. Habitat degradation due to sedimentation occurs when key habitat components such as spawning gravels and cobble surfaces are covered by fine sediment, decreasing inter-gravel oxygen transfer and reducing or eliminating the quality and quantity of pool and interstitial habitat for fish, benthic macroinvertebrates, and algae.

Excessive sediment of anthropogenic origin is a major stressor of aquatic ecosystems in the United States. According to the EPA National Water Quality Inventory-2000 Report, excessive sediment and siltation were identified as leading causes of water quality impairment of the Nation's rivers and streams (USEPA, 2002). In the 2000 Water Quality Inventory, 31% of all river and stream miles were listed as impaired because of sedimentation.

The protection of aquatic life from excess sedimentation originates from the goals and objectives of the Clean Water Act. The protection of aquatic life is a key component of the Clean Water Act objective "to restore and maintain the chemical, physical and biological integrity of the nation's waters." Protection of aquatic life is reinforced in Clean Water Act §101(a)(2) which sets forth the national goal that "…wherever attainable, an interim goal of water quality which provides for protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved." Protection of aquatic life from the adverse effects of excess sedimentation and siltation is provided by the narrative bottom deposits standard.

Arizona's narrative bottom deposits standard is found in the water quality standards rules at A.A.C. R18-11-108(A)(1), which states:

> *A surface water shall be free from pollutants in amounts or combinations that… settle to form bottom deposits that inhibit or prohibit the habitation, growth, or propagation of aquatic life.*

This document establishes the procedures required to implement and interpret the existing narrative bottom deposits standard to prevent excessive sedimentation and siltation in streams in amounts that adversely affect aquatic life.

Defining Excess Sediment as Regulated by the Narrative Bottom Deposits Standard

The narrative bottom deposits standard is intended to regulate excessive amounts of uncontaminated fine sediment in streams which adversely affect aquatic life. Fine sediment is defined as particles that are less than 2 mm in size (i.e., clay, silt and sand). Fine sediment is also defined as "clean" or uncontaminated sediment for purposes of the bottom deposit standard. Excess sediment means an accumulation of fine particles that settle out of the water column to form deposits on the streambed.

ADEQ uses a modified Wolman pebble count procedure (Wolman, 1954; Harrelson, 1994) to calculate the percentage of fine sediment that is present in the stream substrate. In this method, streambed particles are placed into size classes, modified from the Wentworth scale (Wentworth, 1922). These size classes include particles that range from silt and clay to sand, gravel, cobbles and boulders (Table1).

Table 1. Particle size classes used in the Wolman pebble count.

Size Class	**Size Range (mm)**
Silt / Clay	<0.062
Sand	0.063 – 2
Very Fine Gravel	3-4
Fine Gravel	5-8
Medium Gravel	9-16
Coarse Gravel	17-32
Very Coarse Gravel	33-64
Small Cobble	65-96
Medium Cobble	97-128
Large Cobble	129-180
Very Large Cobble	181-256
Small Boulder	257-512
Medium Boulder	513-1024
Large Boulder	1025-2048
Very Large Boulder	2049-4096
Bedrock	>4097

Applicability

The narrative bottom deposits standard applies to all "surface waters." "Surface water" is defined in the surface water quality standards rules at A.A.C. R18-11-101(40). The regulatory definition of "surface water" is as follows:

> A surface water is a "water of the United States" and includes the following:
>
> a. A water that is currently used, was used in the past, or may be susceptible to use in interstate or foreign commerce;
>
> b. An interstate water, including an interstate wetland;
>
> c. All other waters, such as an intrastate lake, reservoir, natural pond, river, stream (including an intermittent or ephemeral stream), creek, wash, draw, mudflat, sandflat, wetland, slough, backwater, prairie pothole, wet meadow, or playa lake, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce, including any such water:
>
>   i. That is or could be used by interstate or foreign travelers for recreational or other purposes;
>
>   ii. From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
>
>   iii. That is used or could be used for industrial purposes by industries in interstate or foreign commerce;
>
> d. An impoundment of a surface water as defined by this definition;
>
> e. A tributary of a surface water identified in subsections (a) through (d) of this definition; and
>
> f. A wetland adjacent to surface water identified in subsections (a) through (e) of this definition.

While the narrative bottom deposits standard technically applies to all surface waters, ADEQ has developed implementation procedures that apply only to wadeable, perennial streams with either an A&Wc or A&Ww designated use. The ADEQ field procedures described in Appendices A and B must be used for determining the percentage of fine sediments in warm water and cold water streams.

Bottom deposits assessments will only be conducted for perennial, wadeable stream segments because the existing research used to develop the implementation procedures is based upon perennial stream data.

The narrative bottom deposits standard will not be applied to the following waterbody types because the research and implementation procedures have not yet been developed:

- Lakes, reservoirs, ponds and playas.
- Large rivers (not wadeable)
- Intermittent streams
- Ephemeral waters
- Effluent dependent waters
- Wetlands

Adverse Effects of Sediment Deposits on Aquatic Life in Streams

Benthic Macroinvertebrates

There is an extensive body of scientific literature documenting adverse impacts of excessive sedimentation and siltation on aquatic life in streams. In a major review of the effects of sediment in streams, Waters (1995) notes that most of the published research dealing with bottom deposits of sediment and benthic macroinvertebrates addresses three major areas: 1) the correlation between the abundance of benthic macroinvertebrates and substrate particle size, 2) the embeddedness of streambed substrates and habitat loss associated with the decrease in the amount of interstitial space or habitat available to benthic macroinvertebrates, and 3) changes in species composition associated with changes in habitat caused by sedimentation.

In an extensive literature review, Chapman and McLeod (1987) found that benthic macroinvertebrate abundance, diversity and species composition was highly correlated with the quantity of fine sediment in stream courses, as follows:

1) Fine sediment is inversely correlated with abundance of aquatic insects. Aquatic insect abundance was reduced 50% with an increase from 7% to 9% fines (<0.84mm) from a sediment core sample (Cederholm and Lestelle, 1974).

2) Insect abundance and diversity generally declined as a result of sediment addition in an Idaho stream (McClelland and Brusven, 1980). Two stoneflies were highly sensitive to bottom sediment and several species of EPT taxa were moderately sensitive to low amounts of sediment but highly sensitive to large increases in bottom sediment. McClelland found that the microhabitat area beneath cobble was very important for most of the EPT taxa he studied.

3) Loss of species and shifts in species composition occurred in streams with increased percent fines. The highest production of aquatic macroinvertebrates was found in streams with gravel to rubble sized substrate (Reiser and Bjornn, 1979). Five species of aquatic insects studied by Brusven and Prather (1974) generally preferred unembedded cobble substrates to half to completely embedded cobble. Nutall (1972) found that sand deposition led to increased abundance of a few macroinvertebrates, such as Tubificid worms and two tolerant mayflies, but also led to loss of many other species.

In a study of 562 stream segments located in four northwestern states, Relyea et al. (2000) found that there are species specific responses to the amount of fine sediment in streambeds and that a Fine Sediment Biotic Index (FSBI) could be constructed, based on aggregated macroinvertebrate sediment tolerance levels, to be used as a predictive tool. While Relyea's work on 83 insect taxa revealed important information about species specific maximum sediment tolerance values, we find the aggregate FSBI scoring categories to be more useful in a regulatory context. For example, specific taxa such as the mayfly *Drunella doddsi* occurred in streams containing <37% fines, but was completely missing at greater levels of fines. For the FSBI, Relyea has placed the 83 taxa she investigated into four scoring categories of intolerant (<30%fines), moderately intolerant (30-50%fines), moderately tolerant (50-70%fines), and tolerant (>70%fines). Of the 83 taxa used to develop the FSBI, there is an aggregate of 29 sediment intolerant taxa which were lost at maximum fine sediment levels of <50% and 54 tolerant taxa found at ranges of 50-100% fines. While species specific tolerance values, especially for taxa found in Arizona, are relevant and important information, the aggregate FSBI scoring categories are a more robust tool for use in standards development.

In a study of stream pollution problems associated with sedimentation and urban runoff in North Carolina, Lenat et.al. (1979) found that density, species richness and diversity were decreased with increased sedimentation. They summarized the effects of sedimentation upon benthic macroinvertebrate communities, as follows: 1) with small amounts of sediment, the density and standing stock of the benthos may be decreased due to reduction of interstitial habitat, although community structure and species richness may not change, and 2) greater sediment amounts that drastically change the substrate type (i.e. from cobble / gravel to sand / silt) will change the taxonomic composition, thus altering community structure and species diversity. The classic example of taxonomic alteration due to sedimentation is a shift from a community of EPT organisms in the stream to one of oligochaetes (worms) and burrowing chironomids (midges).

Fish

The loss or reduction of fish populations has been associated with sedimentation of streams. Waters (1995) categorized the existing scientific literature on the effects of sediment on fish in streams into 4 main categories: 1) the direct effect of suspended sediment, including turbidity; 2) effects on reproductive success of salmonids; 3) effects on reproductive success on non-salmonid, or warm water fishes; and 4) effects of deposited sediment on the habitat of fry, juvenile, and adult fish.

Most of the published research on the effects of deposited sediment in streams relates to effects on fish, particularly salmonids (e.g., salmon and trout). The adverse effects of deposited sediment on the reproductive success of salmonids have been extensively studied. All North American salmon and trout (including inland trout populations of brook, brown, cutthroat, and other trout) use redds in flowing waters as part of their reproductive strategy. Salmonid redds are vulnerable to deposited sediment because the developing eggs, embryos, and newly hatched sac fry in the redd must be supplied by inter-gravel flows of oxygen-rich water. The primary source of oxygen reaching the redd is in the downwelling water of the stream. The deposition of excessive sediment is a major problem because sediment deposits interfere with or prevent the transfer of dissolved oxygen within the redd. When excessive sediment settles to form deposit deposits, adverse effects include the coating of fish eggs and embryos and the filling of interstitial spaces in the redd gravel so that the flow of oxygen-rich water through the redd is impeded or stopped. Three adverse effects of excessive sediment on salmonid redds have been recognized: 1) filling of interstitial spaces in the redd by sediment deposits, thus reducing or preventing the flow of water through the redd and the supply of oxygen to the embryos or sac fry; 2) smothering of embryos and sac fry by high concentrations of suspended sediment entering the redd; and 3) entrapment of emerging fry if an armor of consolidated sediment is deposited on the surface of the redd.

In contrast to salmonid reproduction, the effect of sediment upon reproductive success of warm water fishes is less well known. Waters (1995) notes that correlations between warm water fish species distribution and heavy sedimentation in streams suggest some cause and effect relationship, but only circumstantial evidence is available.

The scientific literature on the subject of deposited sediment and fish habitat has concentrated primarily on fish-rearing habitat. Two major areas of study have been investigated: 1) mortality to fish fry by the filling in of the interstitial spaces in riffles of gravel and cobbles, and 2) loss of juvenile-rearing and adult habitat by the filling of pools. Again, most of the research in this area has been done on salmonids. Salmonid fry require the protection of streambed "roughness" conditions for winter survival. Salmonid fry seek the protection of the interstitial spaces in clean stream bed substrates for over-wintering cover. Although not as extensively studied, there is evidence of the adverse effect of deposited sediment on juvenile rearing habitat in pools. When heavy sediment deposits reduce or eliminate pool habitat, reduced growth and loss of fish populations result. Waters (1995) presumed that fry of warm water fishes have similar habitat requirements for survival of early life stages but Waters states that little research has been done on these sediment relationships for warm water fishes.

Bjornn et. al. (1977) found that when the percentage of fine sediment exceeds 20 to 30 percent in spawning riffles, the survival and emergence of salmonid embryos begins to decline. Bjornn et. al. (1977) advocate using the percentage of fine sediment in riffle areas as the primary indicator for monitoring deposition of fine sediment in streams and for determining when too much sediment deposition is occurring.

Determining Thresholds for the Narrative Bottom Deposit Standard

ADEQ proposes to use separate bottom deposits criteria for warm and cold water streams, based upon our interpretation of the existing literature. Sediment levels of ≤30% fines for cold water streams and ≤50% fines for warm water streams are required to protect aquatic life. These sediment levels will constitute the narrative bottom deposits criteria. The rationale for these criteria is presented below.

The proposed cold water sediment criterion is more protective than the warm water criterion. There are native Arizona trout species resident in our cold water streams, which should be protected at the 30% level of fine sediment, which inhibits propagation of salmonids, as reported by Bjornn et al. (1977). In addition, excess sediment is less common in high gradient, erosional stream types of the cold water, mountain streams of Arizona. The cold water bottom deposits criterion will be applicable to only perennial, wadeable, non-effluent streams at this time. ADEQ's "riffle pebble count" field procedure must be used to determine the percentage of fines in a cold water stream (Appendix A).

The proposed 50% fines criterion is reasonable for warm water streams of Arizona for several reasons. This value is a composite of multiple macroinvertebrate species sediment tolerance values developed by Relyea et al. (2000). Many of these species reside in Arizona's warm water streams. This criterion represents a loss of habitation by aquatic life, namely the aquatic insects. In addition, ADEQ has supporting macroinvertebrate data indicating that sediment effects to macroinvertebrates occur at levels of 40-50% fines in San Pedro River streams (Spindler, 2004). Thus, an initial criterion for warm water streams is set at a greater percentage of fines than for cold water streams. The warm water bottom deposits criterion will be applicable to only perennial, wadeable, non-effluent streams at this time. ADEQ's "reach level" or line-point particle count procedure must be used to support the warm water bottom deposits criterion (Appendix B).

Determining Compliance With the Narrative Bottom Deposit Standard

The percent fines values in Table 2 comprise the numeric thresholds ADEQ will use to determine whether there is a violation of the narrative bottom deposits standard. A violation of the standard occurs when the percent fines, as determined by the appropriate pebble count method, is greater than the numeric criterion in Table 2. These criteria apply only to perennial, wadeable streams with either an A&Wc or A&Ww designated use. The appropriate ADEQ field sampling method must be followed to determine compliance with the narrative bottom deposits standard.

Table 2. Numeric Bottom Deposits Standard Thresholds

Wadeable, perennial stream	Bottom Deposit criterion (percentage of fine sediment <2mm)
A&Wc	> 30 %
A&Ww	> 50 %

Identification of Impaired Waters Based on Violations of the Narrative Bottom Deposits Standard

Impaired

ADEQ will determine that a wadeable, perennial stream is an impaired water for §303(d) listing purposes if there are two or more violations of the narrative bottom deposits standard, as determined in the previous section, within a five-year assessment period. A §303(d) listing because of narrative bottom deposits standard violations requires development of a sediment TMDL.

Inconclusive

The attainment status of the narrative bottom deposits standard is inconclusive where there is only one violation of the narrative bottom deposits standard within a five-year assessment period. A finding of "inconclusive" does not result in the identification of a wadeable, perennial stream as an impaired water. A verification sample is required to determine whether there is a violation of the narrative bottom deposits standard.

De-listing

ADEQ may de-list a wadeable, perennial stream that is on the §303(d) list of impaired waters because of violations of the narrative bottom deposits standard if 1) ADEQ completes and EPA approves a sediment TMDL or 2) Follow-up monitoring indicates that there is only one violation or no violations of the narrative bottom deposits standard within a consecutive five-year period.

Implementation of Narrative Bottom Deposits Standard in AZPDES Permits

The narrative bottom deposits standard at R18-11-108(A)(1) and associated implementation procedures at R18-11-108.02 are <u>not</u> intended to be used as a basis for calculating numeric water quality based effluent limits (WQBELs) in AZPDES permits. Numeric WQBELs to control the point source discharge of sediment may be based on applicable technology-based requirements (e.g., secondary treatment requirements for total suspended solids in 40 CFR, Part 133) or applicable numeric water quality standards for suspended sediment concentration prescribed at A.A.C. R18-11-109(C). ADEQ may develop AZPDES permit conditions which require water quality monitoring of stream bottom deposits consistent with these procedures to assess stream conditions and to confirm effectiveness of best management practices to control discharges of sediment.

Definitions:

Benthic means the bottom of a sea, lake or stream. Benthic macroinvertebrates generally refers to aquatic insects and other invertebrates which reside on stream bottom substrates.

Biological integrity: The capacity of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.

Fine sediment refers to the percentage of particles occurring in the stream substrate, which are less than 2 mm in particle size (i.e., clay, silt and sand).

Index of biological integrity means a multimetric tool used for assessing the condition of a biological community.

Interstitial refers to the spaces between grains of sediment in a stream substrate (interstitial spaces).

Macroinvertebrates are invertebrate animals that are large enough to be seen with the naked eye and have no backbone or spinal column; such as insects, snails, and worms.

Perennial surface water means a surface water that flows continuously throughout the year.

Redd - A spawning nest dug in the streambed substrate by a fish, especially a salmon or trout.

Riffle habitat refers to the portions of streams where moderate velocities and substrate roughness produce moderately turbulent conditions which break the surface tension of the water and may produce whitewater.

Run habitat refers to segments of streams where there is moderate velocity water, but non-turbulent conditions which do not break the surface tension of the water and do not produce whitewater.

Substrate refers to the bottom material in a stream, which is composed of a mixture of particle sizes.

Wadeable means no deeper than can be safely waded across when collecting samples. ADEQ recommends sampling in streams that are flowing at velocities and depths whose quotient is less than 9 (eg. Velocity <4.5ft / s x 2 ft deep).

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Appendix A. Field Procedure for Determining Percent Fines for Riffle Habitats

The percentage of fine sediment in flowing streams is determined using a modified Wolman pebble count procedure (Leopold, et al. 1964). ADEQ has adapted this procedure to obtain a "riffle pebble count", which is used to identify the percent fines throughout the wetted channel where macroinvertebrate collections are made. The riffle pebble count is conducted in riffle or run habitats located within either a 2-meander long stream segment or minimum reach size of 100 meters. The data collected is used to evaluate whether a bimodal particle size distribution exists and to determine the percentage of fine sediment in the substrate, affecting colonization space for aquatic life.

The ADEQ riffle pebble count consists of measuring particles at equal increments across multiple straight transects within the wetted width of riffle habitats where the macroinvertebrates were collected to achieve an approximate 100 count of particles.

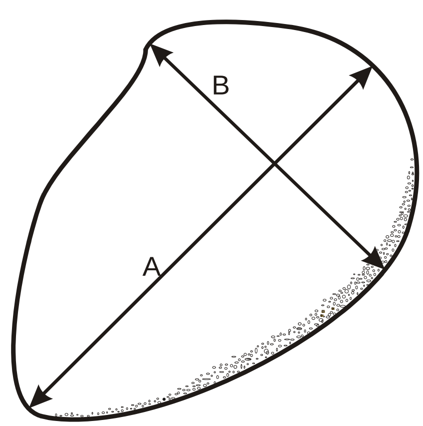
ADEQ Riffle Pebble Count

1. A stream segment of 2 meander length width is first established and marked with flagging tape. Usually three riffles or runs are selected within the stream segment for the pebble count. Pebbles are collected for measurement along transects within each habitat, working from the most downstream transect to the most upstream transect.

2. A tape is set up with bank pins across each transect. If three habitats are worked, divide the stream width by thirty three to obtain the increment needed to collect 33 particles across the transect in a single pass. Do not collect particles closer than 0.3 tenths of a foot apart. If 33 particles cannot be collected in one pass along the transect, make a second or third pass as close as possible to the transect tape, and working in an upstream direction without collecting pebbles from the same area worked in the first pass.

3. Use a marker system to ensure collection of a randomly selected particle. The tip of the pebble count ruler or off the front of a boot, placed at the appropriate station along the transect tape. To take particle readings, reach over the toe of the boot or at the tip of the ruler. Extend the forefinger, and without looking down, pick up the first pebble touched, and measure the intermediate axis (B) in millimeters. The intermediate axis is neither the longest nor shortest of the three mutually perpendicular sides.

   A = Longest Axis (length)
   B = Intermediate Axis (width)
   Thickness = Shortest Axis



   Determine the Size Range from the SEM Field Data Sheet (see attached field form) and record the tally. Embedded rocks are measured in place by measuring the smaller of the two exposed axes. Caution - there is a tendency to look down and select a pebble, but this should be avoided or the results will be biased toward larger particle sizes.

4. Discard the measured pebble downstream, move to the next station, and repeat step 3.

5. Continue working across the transect from wetted edge to wetted edge of the streambed. After completing the first 33 measurements at this transect, move upstream to the next transect, and repeat the process. One hundred counts is the ideal number for this procedure. The whole transect should be completed, rather than stopping data collection in mid-transect when 100 count is obtained. Sample counts are allowed to vary ±10 counts (90-110 particles).

6. Sum the counts before leaving the stream, to ensure that the goal of 100±10 pebbles have been counted. If the count is within a count of ten, it is an acceptable pebble count.

References

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Riffle Pebble Count

For transect method, tally 100-pebbles in riffle habitat only. Measure particles at equal increments across multiple transects within the wetted width of available riffle habitat throughout the stream segment.

Size Class	Size Range (mm)	Tally	Count	Percent	Cum. %
Silt/Clay *	<0.062				
Sand **	0.063 - 2.0				
Very Fine Gravel	3 - 4				
Fine Gravel	5 - 8				
Medium Gravel	9 - 16				
Coarse Gravel	17 - 32				
Very Course Gravel	33 - 64				
Small Cobble	65 - 96				
Medium Cobble	97 - 128				
Large Cobble	129 - 180				
Very Large Cobble	181 - 256				
Small Boulder	257 - 512				
Medium Boulder	513 - 1024				
Large Boulder	1025 - 2048				
Very Large Boulder	2049 - 4096				
Bedrock	>4097				
	Totals				

Comments:	% fines <2 mm	
	# Size Classes	
	D15	
	D50	
Note: * Silt / clay particles feel slick when rubbing between thumb and forefinger.	D84	
** Sand Particles feel gritty when rubbing between thumb and forefinger.		

Appendix B. Line Point Particle Count Procedure

There are multiple ways to perform a pebble count for a particle size distribution. The line point particle count procedure presented here for purposes of developing a particle size distribution for all habitats within a study reach and for obtaining a percent fines value. Additional detail on this modified Wolman pebble count procedure is provided in Harrelson et al. (1994). The line point particle count procedure is conducted within all habitats of a study reach that is either 2-meander lengths long or a minimum of 100 meters long. The 100 count of particle sizes is used to evaluate whether a bimodal particle size distribution exists and to determine the percentage of fine sediment in the substrate, affecting colonization space for aquatic life.

Line Point Particle Count Procedure

Determine total length of sample reach and subdivide into 100 equal lengths (sub-reach). A sample is obtained from each sub-reach providing a total of one hundred measured particles. A sample point is identified by extending a transect line from one bank to the opposite bank, perpendicular to stream flow, at each of the one hundred sub-divisions. A particle is selected along the transect line from a pre-determined position known as the Sample Point Rule.

SAMPLE POINT RULE

The width of the stream determines the number of pre-determined sample points along the sub-reach transect line. Wide streams have more pre-determined sample points than narrow streams; however, only one sample is taken along each sub-reach transect line.

a. For channels having a wetted width less than 16 feet (5 meters), samples are obtained at the following five pre-determined points: edge of water, ¼ width, ½ width, ¾ width, and opposite edge of water. For example, if the wetted width is 12 feet, the five sample points are located at right edge of water (REW), 3 feet (from REW), 6 feet, 9 feet, and LEW.

b. For channels having a wetted width equal to or greater than 16 feet (5 meters), samples are obtained at the following nine pre-determined points: edge of water, 1/8 width, ¼ width, 3/8 width, ½ width, 5/8 width, ¾ width, 7/8 width, and opposite edge of water. For example, if the wetted width is 24 feet, the nine sample points are located at edge of water, 3 feet, 6 feet, 9 feet, 12 feet, 15 feet, 18 feet, 21 feet, and edge of water.

c. In situations where the assessment reach has a mixture of wetted widths less than and greater than 16 feet, substitute the appropriate per-determined point scheme where those changes occur.

d. Select the first particle touched at the predetermined sample point and measure the intermediate axis (neither the longest nor shortest of the three mutually perpendicular sides) in millimeters (See figure below). Determine the size range from the Wentworth size classes provided on the Bed Material Analysis Form and record the tally. Measure embedded rocks in place on the smaller of the two exposed axes. Discard the measured particle downstream and move upstream to the next upstream transect and repeat the measurement procedure at the predetermined sample point. Continue until a total of 100 particles are counted and measured.

Axes of pebble

A = Longest Axis (length)
B = Intermediate Axis (width)
Thickness = Shortest Axis

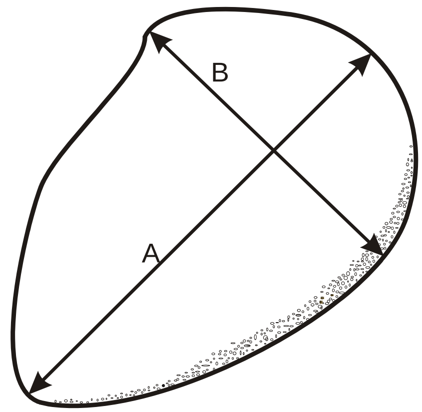


Figure 25. ADEQ pebble count field form.

BED MATERIAL ANALYSIS FORM

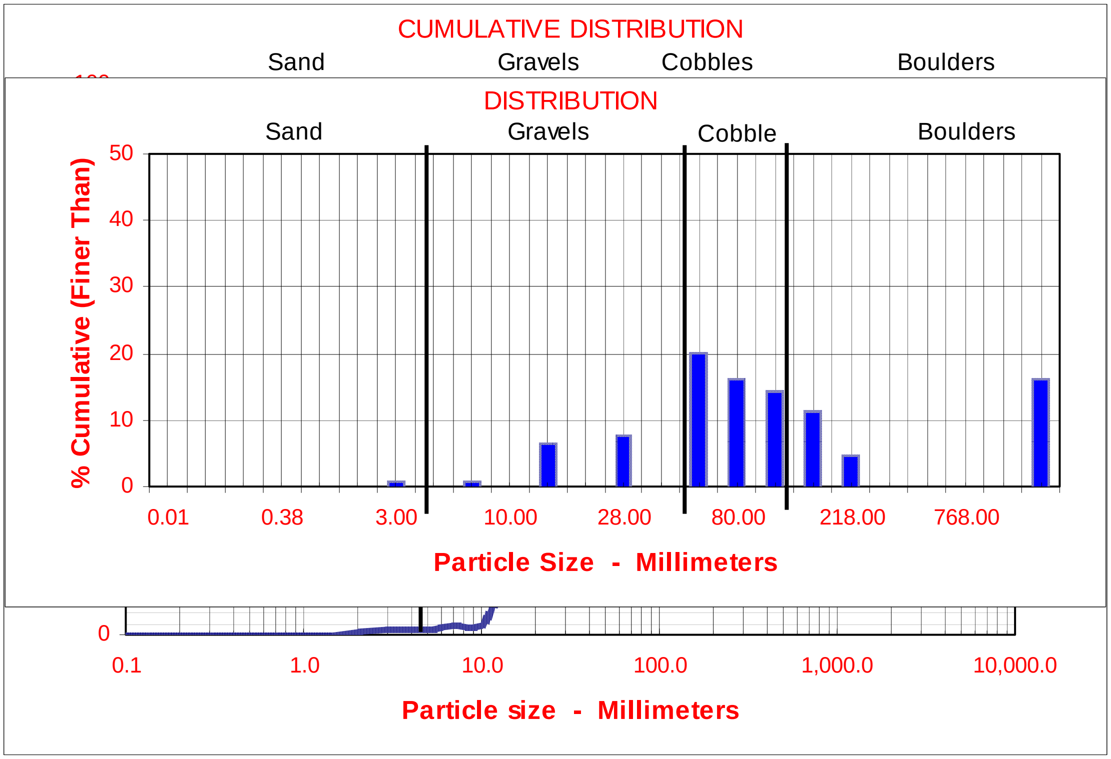
Site Name:____Date:____________

Size Class	Size Range(mm)	Tally	Count	Percent	Cum. %
Silt/Clay*	<0.062				
Sand**	0.063-2				
Very Fine Gravel	3-4				
Fine Gravel	5-8				
Medium Gravel	9-16				
Coarse Gravel	17-32				
Very Coarse Gravel	33-64				
Small Cobble	65-96				
Medium Cobble	97-128				
Large Cobble	129-180				
Very Large Cobble	181-256				
Small Boulder	257-512				
Medium Boulder	513-1024				
Large Boulder	1025-2048				
Very Large Boulder	2049-4096				
Bedrock					
	Totals				

Person Sampling:____________________ PersonRecording:___________________________ Type of Transect:____ Reach Location:____ Particle Size Measurements: Template in ___ N gradation; Calipers: (yes/no); Ruler: (yes/no) Stream Morphology:____ ____ Bed Material Structure & Packing:____ ____ Remarks:____ ____ ____	%Fines (<2mm) # Size Classes D15 = D50 = D84 =

*   Particles feel slick when rubbing between thumb and forefinger
** Particles feel gritty when rubbing between thumb and forefinger

Figure 26. Particle size cumulative distribution graphs, indicating values for D16, D50, D84 and D100 compiled in a bimodal bar chart distribution. The example shows the results of a zig-zag pebble count.



3.16.15.1.1 Literature Cited

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